U.S. Department of Energy
Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

04-WTP-208

Mr. J. P. Henschel, Project Director
Bechtel National, Inc.
2435 Stevens Center
Richland, Washington 99352

Dear Mr. Henschel:

CONTRACT NO. DE-AC27-01RV14136 – APPROVAL OF AUTHORIZATION BASIS AMENDMENT REQUEST (ABAR) 24590-WTP-SE-ENS-03-1261, REVISION 0, *ADDITION OF THE ACTIVATED CARBON BEDS TO THE LAW OFFGAS SYSTEM FOR MERCURY ABATEMENT AND REMOVAL OF CATALYST POISONS*

Reference: BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Transmittal for Approval: Authorization Basis Amendment Request 24590-WTP-SE-ENS-03-1261, Revision 0, 'Addition of the Activated Carbon Beds to the LAW Offgas System for Mercury Abatement and Removal of Catalyst Poisons'," CCN: 0 87891, dated June 23, 2004.

This letter approves the subject ABAR that Bechtel National, Inc. provided to the U.S. Department of Energy (DOE), Office of River Protection (ORP) on June 23, 2004 (Reference). The ABAR proposed to incorporate two activated carbon adsorbers downstream of the melter offgas system exhausters and upstream of the thermal catalytic oxidizer/selective catalytic reactor skid. These adsorbers are for the abatement of mercury and the removal of halides that have been identified as thermal catalytic oxidizer/selective catalytic reactor catalyst poisons.

ORP review of the changes proposed in the subject ABAR and of the changes to the Preliminary Safety Analysis Report (PSAR), Revision 1, is summarized in the attached Safety Evaluation Report (SER). Based upon the information in the Reference and the attached SER, the changes are acceptable with minor modification, and there is reasonable assurance that the health and safety of the public, the workers, and the environment will not be adversely affected by those changes, and that they comply with applicable laws, regulations, and River Protection Project Waste Treatment and Immobilization Plant (WTP) contractual requirements.

The proposed changes to the Low Activity Waste (LAW) PSAR were reviewed for consistency with the changes to the facility design proposed in the ABAR. The approved proposed changes in this ABAR will ultimately serve to update the PSAR. While the proposed changes to the LAW PSAR, as modified, were determined to be consistent with the proposed changes to the facility design as described in the safety evaluation contained in the ABAR, final review of the proposed changes to the PSAR cannot be made until Chapter 2 of the PSAR is available for review. As a result, this SER provides final approval for the general design changes as described in the ABAR, but only interim approval of the proposed specific changes to the LAW PSAR. Final review and approval of the detailed PSAR changes will be made at the time of PSAR update when revisions to Chapter 2 are provided.

One condition of acceptance that involves additional testing to evaluate the potential for accumulating ammonium nitrate in the carbon beds has been identified as a result of this review. The evaluation of ammonium nitrate formation and accumulation has not considered the possibility of a reaction between NOx and ammonia inside the carbon beds when either chemical is adsorbed onto the bed. This postulated mechanism would occur if NOx or ammonia in the offgas stream were adsorbed onto the carbon media and the other chemical reacted to form ammonium nitrate. Ammonium nitrate also may accumulate through gas-phase reactions under certain bounding conditions. The presence of any such ammonium nitrate could invalidate the fire model since ammonium nitrate acts as an oxidizer and was not accounted for in the analysis.

Approval of the ABAR is based upon the Contractor's commitment to complete testing to address the issues noted above, and to select controls as needed to mitigate safety concerns identified through the testing. It is recognized that such testing cannot be accomplished until the design of the carbon beds, the type of carbon media to be used, and other design-related issues are known. Based on this consideration, procurement of the carbon bed equipment is allowed except for the Important to Safety (ITS) equipment for controlling a carbon bed fire. Procurement of the ITS equipment for controlling the fire is allowed once the testing is complete and the necessary control changes are approved by DOE, as necessary.

This amendment is effective immediately and shall be fully implemented within 30 days. If you have any questions, please contact me, or your staff may contact Dr. Walter J. Pasciak, WTP Safety Authorization Basis Team, (509) 373-9189.

Sincerely,

Roy J. Schepens
Manager

WTP:WJP

Attachment

cc w/attach:
M. T. Sautman, DNFSB
J. M. Eller, PAC

**Safety Evaluation Report (SER)
of Proposed Authorization Basis Amendment Request (ABAR)
24590-WTP-SE-ENS-03-1261, Revision 0
of Low Activity Waste (LAW) Facility Changes
for the River Protection Project Waste Treatment and Immobilization Plant (WTP)**

1.0 INTRODUCTION

This SER documents the U.S. Department of Energy (DOE), Office of River Protection (ORP) evaluation of changes proposed by Bechtel National, Inc. (the Contractor) involving the incorporation of two activated carbon adsorbers downstream of the melter offgas system exhausters and upstream of the thermal catalytic oxidizer/selective catalytic reactor (TCO/SCR) skid. These adsorbers are for the abatement of mercury and the removal of halides (including iodine) that have been identified as TCO/SCR catalyst poisons.

2.0 BACKGROUND

The WTP authorization basis is the composite of information provided by a Contractor in response to radiological, nuclear, and process safety requirements that is the basis on which ORP grants permission to perform regulated activities. The authorization basis includes that information requested by the Contractor for inclusion in the authorization basis and subsequently accepted by ORP. The Preliminary Safety Analysis Report (PSAR) describes the analyzed safety basis for the facility, demonstrates that the facility will perform and be operated such that the radiological, nuclear, and process safety requirements are met, and demonstrates adequate protection of the public, workers, and the environment.

The PSAR is based on the preliminary design of the facilities and is part of the authorization basis for WTP construction. ORP authorized construction[1] of the LAW facility based on the facility safety basis documented in the PSAR. Under the requirements of RL/REG-97-13, Revision 10,[2] the Contractor is required to update the PSAR every two years. The amendment request[3] submitted by the Contractor proposes changes to the PSAR that will be incorporated in the PSAR during the next biennial update. This SER documents ORP's evaluation of the facility changes proposed in the reference ABAR, and also evaluates the detailed changes to the PSAR. The enclosed SER provides final approval for the facility design changes as described in the ABAR, but only interim approval of the proposed specific changes to the LAW PSAR. Final review and approval of the specific PSAR changes will be made at the time of PSAR update when revisions to Chapter 2 are provided.

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[1] ORP letter from R. J. Schepens to R. F. Naventi, BNI, "U.S. Department of Energy (DOE) Notice to Proceed with Construction Activities," 02-OSR-0517, dated November 13, 2002.
[2] Office of River Protection Position on Contractor-Initiated Changes to the Authorization Basis, RL/REG-97-13, Revision 10, Department of Energy, December 2003.
[3] BNI letter from J. P. Henschel to R. J. Schepens, ORP, "Transmittal for Approval: Authorization Basis Amendment Request 24590-WTP-SE-ENS-03-1261, Revision 0, 'Addition of the Activated Carbon Beds to the LAW OFFGAS System for Mercury Abatement and Removal of Catalyst Poisons'," CCN: 087891, dated June 23, 2004.

3.0 EVALUATION – General design changes

3.1 Proposed Changes – Addition of Mercury Abatement Skid:

Mercury has been identified as a potential emission from the LAW offgas stream. The proposed design change would incorporate a mercury abatement skid with activated carbon adsorbers downstream of the melter offgas system exhausters and upstream of the thermal catalytic oxidizer/selective catalytic reactor (TCO/SCR) skid for the abatement of mercury and the removal of halides (i.e., HF, HCl, and I_2) that have been identified as TCO/SCR catalyst poisons. The adsorbers will be located on the 48-ft level of the LAW facility.

Two activated carbon adsorbers are proposed, with instrumentation and cross-connect piping for (a) lead/lag operation, or (b) operation with one adsorber on-line and the other adsorber off-line (e.g., for maintenance). Flow will normally be lead/lag.

A continuous emission monitor (CEM) for mercury is provided, with two sensing legs (one connected to each carbon adsorber). The sensing leg in the lead carbon adsorber will normally be open, and the sensing leg on the lag carbon adsorber normally closed. The CEM provides warning of mercury breakthrough so the carbon adsorbers can be switched from lead/lag operation to a configuration where the lead adsorber is bypassed for bed replacement and the lag adsorber removes targeted constituents from the gas stream.

The carbon adsorbers are equipped with temperature instrumentation to detect carbon bed temperatures. Temperature instrumentation is also provided across the mercury abatement skid to detect a change in offgas flow temperature. The carbon adsorbers are connected to a water source that can be used to cool or submerge the bed if a carbon fire is suspected.

Evaluation (acceptable): Plugging of the adsorber beds or the offgas system and carbon fires were identified as potential hazardous events. Plugging or isolation of the adsorbers would obstruct melter offgas flow, which could result in melter pressurization and NOx release inside the facility. The carbon bed fire could cause adsorbed mercury, SOx, and I-129 to be released from the sulfur-impregnated, activated-carbon media. The presence of adsorbed halides on the bed also may contribute to the formation of phosgene and other hazardous gases in a fire.
For plugging of the adsorber beds or offgas system specific engineered features credited are:

- Differential pressure is monitored to detect blockage of offgas flow through the mercury abatement skid. A bypass valve is automatically opened to divert offgas flow around the mercury abatement skid should a high differential pressure across the unit be detected, indicative of an obstruction or blockage of flow. The reviewers concluded the bypass is acceptable for ensuring an open vent path for melter offgas in the event of blockage of offgas flow through the mercury abatement skid.

- Liquid level instrumentation in each of the carbon adsorber units detects a high liquid level in the adsorber bed. Upon detection of a high liquid level in the adsorber bed, an isolation valve in the carbon bed water addition line closes to prevent further water flow to the carbon beds. The reviewers concluded this control is acceptable for ensuring that blockage of the offgas system due to flooding of lines upstream or downstream of the mercury abatement skid does not occur, should the water supply to the carbon adsorber bed be inadvertently or intentionally activated.

For potential carbon fires, the specific engineered features credited to reduce the risk associated with carbon fires are:

- Instrumentation to measure carbon oxides concentration (CO and CO_2) is located before and after the carbon adsorbers to sense any significant oxidation of carbon, which would signal the onset of combustion in the carbon adsorbers. On detection of high differential COx concentration across the mercury abatement skid, interlocks automatically (1) open the bypass valve to divert offgas flow around the mercury abatement skid, and (2) close the inlet isolation valves to both carbon adsorbers. The reviewers concluded that closure of the isolation valves would effectively limit the oxygen supply to the carbon adsorbers, thereby limiting combustion and the release rate of toxic materials.

  Closure of the inlet valve may enable CO to be generated and accumulate in the open spaces of the adsorber vessels and the isolated offgas pipelines if an undetected fire in the carbon bed is slowly burning. CO is explosive over a range of 12 to 75 volume percent CO in the gas phase. The four temperature sensors in each bed will be generally ineffective in detecting a typical small fire in the ~15-ft. diameter carbon bed. The small fire could be supported by oxygen in the offgas that diffuses or flows at a low rate through the carbon bed outlet line that is left open to the melter offgas stream. The formation of CO rather than CO_2 is favored when burning occurs under the starved-oxygen conditions that will exist when the beds are partially isolated as planned. Under partially isolated conditions, oxygen may be replenished to the area of the small fire by convective gas currents induced within the carbon bed by the fire's thermal gradient.

  Three mechanisms were identified as potential initiators of a carbon fire that could result in generating CO. These mechanisms include an over-temperature fault in the HEPA filter pre-heater, insufficient offgas cooling by the submerged bed scrubber, and a spike in the release of organics from the melter, resulting in high adsorption heat in the carbon beds. SDC temperature and COx controls have been established to prevent the first two of the three mechanisms, and the third mechanism was found to be beyond extremely unlikely due to thermodynamic limitations. A fourth mechanism that was not evaluated involves the postulated presence of ammonium nitrate in the beds. The reviewers concluded that further testing must be performed to determine if ammonium nitrate can accumulate in the beds and, if so, the safety impacts of such accumulations, including the potential for generating CO during a fire that involves a reaction between the carbon and the ammonium nitrate. See Condition of Acceptance (COA) No. 1 in Section 5.0 of this SER.

  Temperature instrumentation is located at the inlet of the mercury abatement skid to sense excessive melter offgas temperatures that could cause bulk ignition and burning of the carbon adsorber beds. On detection of high offgas temperature at the inlet of the mercury abatement skid, interlocks automatically (1) open the bypass valve to divert offgas flow around the mercury abatement skid and (2) close the inlet isolation valves to both carbon adsorber bed units. The reviewers concluded closure of the isolation valves is acceptable for preventing high temperature flows to the carbon adsorbers, thus preventing bulk heating and potential ignition of the carbon media.

- The melter offgas system confinement boundary is required to confine the toxic vapors, gases and aerosols produced in a carbon bed fire and direct these materials through the LAW exhaust stack. This confinement boundary prevents exposures to facility workers. Although the conditions for the design-basis fire have not yet been established, the Contractor will ensure that the downstream piping and the carbon bed vessels will be designed to accommodate the thermal effects of the fire and maintain confinement of the offgas. This confinement boundary for protection of workers is being designated as a safety design significant (SDS) structure, system, or component (SSC). The Safety Requirements Document (SRD) has requirements that will cause the confinement boundary to be designed to the environmental conditions expected during a fire. The potential formation of ammonium nitrate within the carbon bed by adsorbed phase reaction between NOx and ammonia has not been addressed in prior Contractor hazards analyses. Ammonium nitrate also may accumulate through gas-phase reactions under certain bounding conditions. The formation of ammonium nitrate by these mechanisms could invalidate the fire model used for the carbon bed because the ammonium nitrate acts as an oxidizer, which is not taken into account by the fire model. The selected control strategy for the fire could also be invalidated. Testing of the potential ammonium nitrate formation and subsequent impacts to the combustion rate of the carbon media would resolve this issue. The reviewers concluded that kinetic and heat-of-reaction data obtained from the testing should support a determination of whether controls to prevent or to otherwise mitigate significant ammonium nitrate accumulations are necessary. The reviewers concluded that controls are available to achieve both prevention and mitigation, if required. Based on these considerations, approval of this ABAR is conditional upon completion of testing, hazards analysis, and selection of adequate controls to close this issue. Because the Contractor has not yet established the environmental conditions the confinement boundary would be subjected to in a fire, it is necessary that the testing, hazard analysis, and selection of controls be a COA of this ABAR to ensure that the confinement boundary be able to function in the expected environmental conditions during a fire. This COA is described in Section 5.0 of this SER.

- The exhaust path from the carbon adsorbers is maintained open to allow heat and fire products to vent from the carbon adsorbers. The exhaust path connects to the secondary offgas header downstream of the bypass valve and is thus pressurized by the offgas exhausters. During a fire this leg will stagnate, except for any minor flows generated due to isolation valve leakage or back diffusion of gases from the secondary offgas header. The design and configuration of the exhaust piping is relied on to minimize backflow of oxygen via this path into the carbon adsorbers. The total inflow of oxygen into both carbon adsorbers due to isolation valve leakage and due to backflow via the exhaust path will be maintained within the limiting value determined in the LAW Fire design basis event (DBE) analysis. In addition to SSC controls, administrative controls have been established for the carbon adsorber beds to reduce the likelihood of carbon bed fires during startup, operation, and maintenance activities. The reviewers concluded the SSC and administrative controls are likely to be effective in mitigating the fire hazard.

4.0 EVALUATION – SPECIFIC CHANGES TO PSAR, REVISION 1

4.1 Proposed Revised Text – Section 3.3.3.2, "Melter Systems":

To the first paragraph on p.3.3-5, the following sentence has been added to the end of the paragraph:

> "A fire in one or both carbon adsorbers is also identified as an event with the potential to produce significant chemical exposures outside the facility, by allowing a ground level release of NO_x, adsorbed mercury, and phosgene (and other halogenated gases). The fire also may release I-129, resulting in minor radiological exposures to the public and co-located worker."

ORP reviewers added "and phosgene (and other halogenated gases)" and the last sentence addressing I-129 to the Contractor's proposed text.

Evaluation (acceptable, as modified): This change, as modified, adds technical details describing the consequences of a fire in the carbon adsorbers. The change is consistent with the changes described and evaluated in Section 3.1 above. The Contractor evaluated the hazards associated with the release of mercury and sulfur dioxide during a carbon bed fire as documented in CCN: 082921, *Safety Assessment to Support LAW Mercury Adsorber Unit Addition ABAR 24590-WTP-SE-ENS-03-1261, Addition of the Activated Carbon Beds to the LAW Offgas System for Mercury Abatement and Reduction of Catalyst Poisons.* The evaluation showed the unmitigated consequences of the fire exceed the mercury Temporary Emergency Exposure Limit (TEEL) values by approximately three orders of magnitude for co-located worker exposure and approximately two orders of magnitude for public exposure. Unmitigated co-located worker exposure to sulfur dioxide was determined to be more than an order of magnitude higher than the TEEL value. The mitigated exposures to the public and the co-located worker were determined to be well below the TEEL values, and therefore, meet the requirements of Safety Criterion 2.0-2.

The Contractor also evaluated the consequences of the release of a two-year accumulation of I-129 in the fire and found the consequences to the on-site receptor to be well below the SL-3 limit. The evaluation of the I-129 release is documented in a Contractor evaluation dated August 31, 2004.[4] The Contractor did not evaluate the consequences of the release of phosgene and other halogenated gases formed during the fire. The ORP reviewers considered the lack of this analysis acceptable since the controls required to prevent and mitigate the release of mercury and sulfur dioxide in the event of a fire would be effective in preventing and mitigating the release of phosgene and other halogenated gases.

4.2 Proposed Revised Text – Section 3.3.3.2, "Melter Systems":

In the subsection, "Identification of Control Strategies" the following text is to be added at locations indicated in the ABAR:

[4] "Potential I-129 release in Carbon Bed Fire," CCN: 095852, dated August 31, 2004.

> "The mercury abatement skid bypass valve is opened on detection of high differential pressure across the skid, to preclude restriction in offgas flow due to bed plugging or flooding. The bypass valve is also actuated on detection of high carbon oxide levels and high offgas temperature as part of the carbon bed fire control strategy. In addition, the carbon adsorber water addition valve(s) are isolated on detection of high liquid level in the bed. This prevents flooding of the secondary offgas system with water.
>
> Carbon bed fires are possible in the mercury abatement skid carbon adsorbers. Carbon oxides (CO and CO_2) concentration monitors are located at the inlet and outlet to the mercury abatement skid. A fire will produce a significant increase in either CO or CO_2 concentration across the skid. On detection of high differential CO or CO_2 concentration across the skid, inlet isolation valves to both carbon adsorbers are closed. This limits flow of oxygen to the fire, thus limiting the rate of release of adsorbed mercury and other carbon fire products into the secondary offgas system. The inlet isolation valves are also closed on detection of high offgas temperature at the inlet to the mercury abatement skid. This prevents hot offgas from causing bulk heating and ignition of the carbon media.
>
> The mercury abatement skid bypass valve is opened on detection of high differential CO_x concentration across the skid, or detection of high inlet offgas temperature, to ensure a continuous unobstructed flow path for melter offgas when the carbon adsorber isolation valves are to be closed. Administrative controls have also been established to reduce the likelihood of carbon bed fires during startup, operation, and maintenance activities."

<u>Evaluation (acceptable):</u> This change adds technical details describing the control strategies for the mitigation of fires in the carbon bed. The control strategies involve opening the bypass valve on detection of high differential pressure across the skid, high differential CO_x concentration across the skid, or detection of high inlet offgas temperature. These strategies will minimize the possibility of the start of a fire and if one occurs, releases from it. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.3 <u>Proposed Revised Text – Section 3.3.5.2, "Chemical Consequences":</u>

Changes are proposed to this section to address chemical releases resulting from a plugged or flooded carbon adsorber bed or by fire damage to the offgas system confinement boundary. In addition, these consequences previously did not reach the safety design class (SDC) threshold for chemical consequences to the public, whereas as a result of this change, they now do. The specific changes are as follows:

The second to last sentence of the first paragraph is to read as follows:

> "A summary of the events identified for LAW that could conceivably result in exceeding a safety design class (SDC) threshold for consequence to the co-located worker or public is presented in 24590-LAW-RPT-ENS-03-001."

The second paragraph is to read as follows:

> "The release of NO_x from the LAW melter offgas system due to an offgas release or fire can be attributed, in general, to the following types of initiating events;"

The third bullet is to read as follows:

> "Releases caused by the blockage and pressurization of the offgas system (e.g., flooded SBS, saturated or blocked offgas HEPA filter, plugged or flooded carbon adsorption bed)"

A new bullet is to be added that reads as follows:

> "Releases caused by fire damage to the offgas system confinement boundary (e.g., fire damage in carbon adsorption bed)"

A new paragraph is to be added after the bullets reading as follows:

> "The carbon bed fire scenario has the potential to release significant quantities of mercury and sulfur oxides, in addition to causing a potential NO_x and phosgene release."
>
> ORP reviewers added "and phosgene" to the Contractor's proposed text.

Evaluation (acceptable, as modified): This change adds technical details describing consequences associated with chemical releases. The change is consistent with the changes described and evaluated in Section 3.1 above and the control strategies proposed to be added to Section 3.3.5.2. The reviewers added phosgene since its creation from CO and halides released from the carbon in the event of a fire is thermodynamically favored.

4.4 Proposed Revised Text – Section 3.3.5.2, "Chemical Events":

The Contractor proposed to add four new Control Strategy Development (CSD) records to address plugged offgas events. The CSD record numbers are CSD-LLVP/N0026, CSD-LLVP/N0028, CSD-LLVP/N0029, and CSD-LLVP/N0030.

In CSD-LLVP/N0026, isolation valves to the activated carbon beds are inadvertently closed resulting in pressurization of the melter and release of NO_x to the melter gallery. In CSD-LLVP/N0028 attrition of the carbon adsorber media plugs the discharge roughing filter and blocked offgas flow results in loss of melter vacuum and the release of offgas to the melter enclosure and potentially to the Melter Gallery. In CSD-LLVP/N0029, deposition of ammonium nitrate in an activated carbon bed is postulated to result in plugging of the bed or discharge roughing filters resulting in melter pressurization and a NO_x release to the melter enclosure and gallery. In CSD-LLVP/N0030, water for controlling fires in the carbon beds floods a bed and overflows into the secondary offgas system, obstructing melter offgas flow. This results in pressurization of the melter and a NO_x release to the melter enclosure and gallery.

The Contractor proposed to add five new CSD records to address fire events. The CSD record numbers are CSD-LLVP/N0025, CSD-LLVP/N0031, CSD-LLVP/N0032, CSD-LLVP/N0034, and CSD-LLVP/N0035.

In CSD-LLVP/N0025, a smoldering fire occurs in a carbon adsorption bed due to increased heat of adsorption caused by elevated levels of organics in the melter offgas. This event results in failure of the carbon adsorber and melter offgas confinement boundary, resulting in a release of NO_x, sulfur oxides (SO_x), mercury vapor, and potentially phosgene to the secondary offgas room. In CSD-LLVP/N0031, the closure of the inlet and outlet control valves to the carbon adsorber beds results in isolation of the beds. Loss of air flow results in overheating of the carbon bed and a smoldering fire that pressurizes the carbon adsorber and releases sulfur oxides (SO_x) gases, mercury, and potentially phosgene. In CSD-LLVP/N0032, impurities associated with the activated carbon media react with NO_x, resulting in a smoldering fire that releases the mercury, sulfur, and potentially phosgene from the bed. In CSD-LLVP/N0034, failure of a HEPA filter preheater or mercury abatement skid startup preheater causes hot gas to flow through carbon adsorbers igniting the carbon media and releasing mercury, $SO_{x,}$ and potentially phosgene. The event may cause failure of the carbon adsorber confinement boundary with release of mercury, SO_x, potentially phosgene, and NO_x to the secondary offgas room. In CSD-LLVP/N0035, a carbon adsorber opened for maintenance or to change out carbon media while a hot spot in the media remains near the ignition temperature results in ignition of the carbon media, causing the release of mercury, $SO_{x,}$ and potentially phosgene into the secondary offgas room. Several years of adsorbed I-129 could also be released to the room in this scenario.

ORP reviewers added "and potentially phosgene" to the Contractor's proposed text.

<u>Evaluation (acceptable, as modified):</u> This change adds reference to new CSD records that provide control strategies for the changes proposed in this ABAR. The control strategies in these CSD records are consistent with the consequences described in this PSAR Section 3.3.5.2, and evaluated in Section 3.1 above. The reviewers added phosgene since its creation from CO and halides released from the carbon in the event of a fire is thermodynamically favored.

4.5 <u>Proposed Revised Text – Section 3.4.1.1.1.6, "Requirements for Selected Control Strategy":</u>

The Contractor proposed to add the following subsection:

<u>"Mercury Abatement Skid</u>

- Melter offgas system design includes a bypass around the mercury abatement skid which is actuated on high differential pressure or high differential CO or CO_2 concentration across the skid, or high inlet offgas temperatue.
- An isolation valve on the water supply to the carbon adsorbers will be shut, by interlock, when high liquid level is detected in the carbon adsorber. This control prevents flooding of the secondary offgas system with the water supply to the carbon adsorbers."

The first bullet was modified by the ORP reviewers because it only addressed high differential pressure and failed to address high differential CO or CO_2 and high inlet offgas temperature.

Evaluation (acceptable, as modified): This change added a description of the requirements for the control strategies associated with the change. The high differential CO or CO_2 and high inlet offgas temperature control strategies were identified previously in the ABAR submittal by the Contractor and are to be included in the referenced subsection for completeness.

4.6 Proposed Revised Text – Sections 3.4.1.3, "Carbon Bed Fire," and its subsections:

These sections add the accident analysis for internal design basis events associated with carbon bed fires. The proposed changes, twelve pages in length, are not being provided in this SER because of the length. The proposed pages are contained in Attachment 1 of the ABAR.

In response to ORP reviewer questions concerning the possibility of accumulating explosive levels of CO in the offgas leg that is isolated in the event of a carbon bed fire, the Contractor evaluated and documented this potential hazard in CCN: 097686, *Evaluation of Potential for CO Deflagration in the Secondary Offgas System.* The Contractor agreed to add after the third paragraph in Section 3.4.1.3 the following summary statement regarding the potential CO deflagration hazard:

> "The potential for generating explosive levels of CO within an isolated adsorber vessel bed was also investigated and reported in CCN 097686, *Evaluation of Potential for CO Deflagration in the Secondary Offgas System.* A slow burning fire in the carbon bed was postulated to be replenished with enough oxygen due to leakage of the isolation valve or backflow of offgas to produce primarily CO instead of $CO_{2.}$ Three mechanisms were identified as potential initiators of a carbon fire. Controls have been established to prevent two of the three mechanisms, and the third mechanism was found to be beyond extremely unlikely due to thermodynamic factors. Thus, a CO explosion is a beyond extremely unlikely event for the three mechanisms considered. A fourth mechanism that was not evaluated involves the postulated presence of ammonium nitrate in the beds. Further testing will be performed to determine if ammonium nitrate can accumulate in the beds and, if so, the safety impacts of such accumulations."

Evaluation (acceptable, as modified): This change added a description of the revised accident analysis for carbon bed fires. The ORP reviewers agreed with the Contractor's conclusion that the CO deflagration event is beyond extremely unlikely because the three potential mechanisms that could cause the deflagration are either precluded by current ITS temperature controls that prevent overheating of the carbon beds, leading to a fire and CO generation, or are incredible due to the thermodynamic limitations of the offgas/carbon bed system. The reviewers also agreed with the Contractor's conclusion that the CO deflagration analysis must be reevaluated if testing shows the potential for significant accumulations of oxidizers such as ammonium nitrate in the beds. See the COA in Section 5.0 of this SER regarding this testing.

4.7 Proposed Revised Text – Appendix 3A, "Table 3A-3":

The contractor proposed changes to Table 3A-3, which lists the hazardous characteristics of LAW process chemicals and potential by-products. The significant entries for these categories are as follows:

For mercury, as a sulfide compound the following entries are proposed:

- Acute toxicity: "Sulfides of heavy metals are generally insoluble and hence have little toxic action except through the liberation of hydrogen sulfide. Mercury is a general protoplasmic poison with effects on the skin, central nervous system, respiratory system, kidneys and eyes. Acute exposure to mercury vapors or inhalation of respirable mercury compounds may cause tremors, psychic disturbances and other effects on the central nervous system."

- Chronic Toxicity: "Chronic exposure via inhalation may cause mercury poisoning. Chronic ingestion can cause kidney and liver damage."

For sulfur-impregnated activated carbon the following entries are proposed:

- Acute toxicity: "Mild irritation to the respiratory tract."

- Chronic toxicity: "Prolonged exposure to excessive dust may produce pulmonary disorders."

- Flammable/explosive: "Fire is possible at elevated temperatures or by contact with an ignition source. Fine dust dispersed in air in the presence of an ignition source is a potential dust explosion hazard."

- Reactive: "Incompatible with strong oxidizing agents such as nitrates or chlorates."

<u>Evaluation (acceptable.)</u> The potential for a dust explosion caused by the sudden dispersal of collected carbon dust on the carbon bed air vent filter is an occupational hazard that is not within the scope of the Authorization Basis. Also, the incompatibility of sulfur-impregnated carbon with nitrates is addressed in Section 4.7 of this SER and a COA that requires testing to establish the potential for accumulating unsafe levels of ammonium nitrate in the carbon beds is provided in Section 5.0. This change adds technical details describing the hazards associated with mercury and sulfur impregnated activated carbon. The reviewers determined that the additions accurately describe the hazards. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.8 <u>Proposed Revised Text – Appendix 3A, "Table 3A-4":</u>

Table 3A-4 provides a LAW chemical interaction matrix for chemicals used in the facility. Entries have been added to the table to describe the reaction between sulfur-impregnated carbon and other chemicals used at the LAW facility. In all cases there is no adverse reaction expected.

<u>Evaluation (acceptable):</u> This change adds technical details describing the chemical reaction between sulfur-impregnated carbon and the other chemicals used in the LAW facility. The reviewers assessed the entries in the table and concur that there is no adverse interaction. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.9 Proposed Revised Text – Appendix 3A, "Table 3A-22":

Table 3A-22 provides a list of events involving the loss of melter offgas system flow DBE scenarios. Four new entries were added to the table as indicated below:

ISM Events Represented by the Loss of Melter Offgas System Flow DBE Scenario

Initiator	Event
Blockage or Breach of the Offgas System	
Offgas inlet valve to carbon adsorbers is inadvertently closed	Blocked offgas flow results in loss of melter vacuum and release of offgas to the melter enclosure with potential for leakage to the melter gallery.
Attrition of the carbon bed media results in plugging of a carbon adsorber discharge roughing filter	Blocked offgas flow results in loss of melter vacuum and release of offgas to the melter enclosure with potential for leakage to the melter gallery.
Deposition of ammonium nitrate causes plugging of the carbon beds	Blocked offgas flow results in loss of melter vacuum and release of offgas to the melter enclosure with potential for leakage to the melter gallery.
Carbon adsorber flooded with water due to leak in the water supply valve, inadvertent opening of the water supply valve, or intentional opening of the water supply valve to mitigate a carbon bed fire. Water overflows into the secondary offgas piping and blocks offgas flow.	Blocked offgas flow results in loss of melter vacuum and release of offgas to the melter enclosure with potential for leakage to the melter gallery.

Evaluation (acceptable): This change adds technical details describing the hazards associated with the mercury abatement skid. The hazards described are consistent with those described in other sections of this SER and evaluated in Section 3.1 above.

4.10 Proposed Revised Text – Section 4.3.3.1, "Credited Safety Function":

The Contractor proposed to add the following three bullets to this section. They provide credited safety functions to confine fire products to prevent a release inside the facility, to monitor carbon oxides and to bypass the skid on high differential carbon oxides, to bypass the skid on high temperature in the offgas stream, and to bypass the skid on high differential pressure.

- "The components of the melter offgas system from the carbon adsorber vessels through the exhaust stack are relied on to provide a ventilation path for gases and vapors produced in a carbon bed fire. These components must confine the fire products to prevent a release inside the facility, for the protection of facility workers.

- Carbon oxides (CO_x) concentration monitors across the mercury abatement skid are credited with early detection of a fire in one (or both) of the carbon adsorber beds. On detection of high differential CO or CO_2 concentration across the mercury abatement skid (above predetermined setpoints), an interlock opens the mercury abatement skid bypass valve and closes the offgas inlet valves to both carbon adsorbers. This control strategy limits oxygen flow to the carbon bed fire (section 3.4.1.3). The accident analysis (Section 3.4.1.3) demonstrates that chemical exposures to the co-located and public receptors are reduced to below threshold values by controlling the flowrate of offgas or air to the fire.

- Temperature and pressure sensors in the melter offgas system are credited (SDS and SDC) to detect high temperature in the offgas stream to the mercury abatement skid, and high differential pressure across the beds. On detection of high offgas temperature or high differential pressure (above predetermined setpoints), the mercury abatement skid bypass valve is opened, by interlock, and the inlet isolation valves to both carbon adsorbers are closed, by interlock. These control interlocks are necessary to prevent bulk ignition and burning of the carbon media, or pressurizing the LAW melter plena, due to (1) an over-temperature fault in the HEPA filter or carbon bed preheaters, (2) inadequate cooling of the melter offgas in the upstream film coolers and submerged bed scrubber, or (3) pluggage of the beds (section 3.4.1.3)."

The last bullet above was modified by ORP reviewers to add clarity to the discussion of the temperature and pressure sensors.

Evaluation (acceptable as modified): This change adds technical details describing the credited safety function associated with the mercury abatement skid. The proposed discussion, with the modifications shown to the text in the third bullet, is consistent with the control strategies discussed above, e.g. in Sections 4.6. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.11 Proposed Revised Text – Section 4.3.3.3, "Functional Requirements":

The Contractor proposed to add the following four bullets to this section. They provide functional requirements for the safety functions to confine fire products to prevent a release inside the facility, to monitor carbon oxides and to bypass the skid on high differential carbon oxides, to bypass the skid on high temperature in the offgas stream, and to bypass the skid on high differential pressure.

"For the carbon bed fire (Section 3.4.1.3), the following controls are required to limit the oxygen flowrate to the fire and to ensure fire products are confined.

- Carbon oxides (COx) concentration monitors across the mercury abatement skid are required to detect increases in CO and CO_2 concentration in the offgas stream, indicative of a carbon bed fire. Upon detection of differential CO or CO_2 concentration above pre-determined setpoints, interlocks are required to (1) open the mercury abatement skid bypass valve, and (2) close the offgas inlet valve to both carbon adsorbers. The COx monitors and isolation valve interlock are required to detect the carbon bed fire and close the carbon adsorber isolation valves within the time frame determined in the accident analysis. The bypass valve interlock is necessary to ensure melter offgas flow is not obstructed when the carbon adsorber isolation valves are closed.

- The total inflow of oxygen to the isolated carbon adsorbers must be within the limiting value determined in the mitigated accident analysis (3.4.1.3). The total oxygen inflow limit must account for both leakage through the isolation valves and backflow of oxygen (due to countercurrent flow or diffusion) via the open exhaust leg from the carbon adsorbers. The configuration of the exhaust path from the carbon adsorbers must ensure oxygen backflow into the carbon adsorbers is minimized.

- A temperature monitor on the offgas inlet to the mercury abatement skid is required to detect hot offgas flow that may be capable of causing bulk ignition and burning of the carbon media. A carbon-bed differential pressure monitor is required to detect pluggage. On detection of high offgas temperature or pluggage (above pre-determined setpoints), interlocks are required to (1) open the mercury abatement skid bypass valve and (2) close the offgas inlet valve to both carbon adsorbers. These controls isolate the carbon media from the hot offgas and preclude bulk ignition and burning or pressurization of the LAW melter plena. The high offgas temperature interlocks must ensure that offgas flow through the carbon media does not approach the ignition temperature of the carbon media. The bypass valve interlock is necessary to ensure melter offgas flow is not obstructed when the carbon adsorber isolation valves are closed. Accumulations of liquids, dust, and precipitates (including ammonium nitrate) in the dead legs on both sides of the bypass valve must be prevented to enable the bypass line to carry the offgas flow without pressurizing the melter plena.

- The carbon adsorber vessels and melter offgas components downstream of the carbon adsorbers must provide a confinement boundary and unobstructed flowpath to the exhaust stack during a carbon bed fire. The melter offgas confinement boundary precludes releases of I-129, NOx, mercury and sulfur dioxide inside the facility, and thus precludes exposures to facility workers. The carbon adsorber confinement boundary is required to be designed to withstand the elevated temperatures associated with the carbon bed fire."

ORP reviewer modified the third and fourth bullet above to add clarity to the discussion associated with the differential pressure monitor, pressurization of the LAW melter plena, and dead legs on both sides of the bypass valve.

<u>Evaluation (acceptable as modified):</u> This change, with the modifications, adds technical details describing the functional requirements for the safety function associated with the mercury abatement skid. The proposed discussion is consistent with the control strategies discussed above, e.g. in Sections 4.6. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.12 <u>Proposed Revised Text – Section 4.3.3.4, "Standards":</u>

The Contractor proposed to add the following text to this section to provide standards descriptions for safety functions.

"The carbon bed vessels and melter offgas components downstream of the carbon beds are also designated SDC to confine mercury and other toxic vapors and gases produced in a carbon bed fire event."

"ISA S84.01 is a standard applied for all automatically executed safety functions, and thus applies to the design of the carbon adsorber carbon oxides (CO_x) concentration monitors and isolation valve shutdown interlocks. This standard also applies to the high temperature and high differential pressure bypass interlock for the mercury abatement skid. IEEE 338 will be applied in designing the CO_x concentration/isolation valve interlocks, the high temperature bypass interlock, and the high differential pressure interlock, to ensure they can be properly tested for verification of the required safety functions."

The ORP reviewers modified the above paragraph to include high differential pressure interlock as also requiring the application of the subject standard.

Evaluation (acceptable as modified): This change, with the modifications, adds a description of the standards for the safety functions associated with the mercury abatement skid. It is appropriate that safety functions associated with the mercury abatement skid are designated SDC due to the unmitigated chemical consequences in the event of a fire that exceed TEELs for the public and co-located worker. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.13 Proposed Revised Text – Section 4.3.3.5, "System Evaluation":

The Contractor proposed to add the following text to this section to provide an evaluation of the functional requirements against the design.

To the end of the first paragraph in the subsection, "Exhaust Path":

"The carbon adsorber vessels and downstream components must maintain a pressure boundary to provide an exhaust path for noxious gases and vapors that could be released in a carbon bed fire accident."

The following subsection was added:

"Mercury Abatement Skid Fire Controls

Carbon bed fires typically initiate at a small hot spot and grow over time, if oxygen flow to the affected carbon bed is not isolated. Carbon oxides (CO_x) monitors located in the offgas inlet and exhaust paths from the mercury abatement skid are relied on to detect the carbon bed fire before it grows to the point where the mercury release rate produces exposures approaching threshold limits. The outlet CO_x (CO and CO_2, as necessary) concentrations are compared against the inlet CO_x (CO and CO_2) concentrations to determine if carbon is being significantly oxidized within the carbon adsorber beds, indicating the presence of a fire. On detection of high differential CO_x concentration across the mercury abatement skid, automatic interlocks are relied on to (1) open the mercury abatement skid bypass valve, and (2) close the offgas inlet valves to both carbon adsorbers. This control strategy isolates the carbon media from the offgas stream, limiting the available oxygen to the carbon fire.

Limiting the oxygen available to the fire limits the carbon combustion rate and the release rate of adsorbed mercury from the fire. The accident analysis defines the maximum acceptable inleakage rate of oxygen to the fire that will ensure a below-threshold exposure to the co-located worker. The isolation valves are required to ensure a total inleakage rate of oxygen into the carbon adsorbers less than the limiting value determined in the accident analysis. The interlock control logic will ensure the mercury abatement skid bypass valve is opened prior to closure of the carbon adsorber inlet isolation valves. This will ensure a continuous unobstructed flow path for melter offgas, preventing a pressurized release from the melter. The secondary offgas system pressure boundary will confine the melter offgas, and the mercury vapor and other noxious materials released in the carbon bed fire, preventing facility worker exposures. The carbon oxides (CO_x) monitors, carbon adsorber inlet isolation valves and associated interlocks are designated ITS, safety design class (SDC), to ensure the fire is detected, the oxygen supply to the carbon adsorbers is appropriately restricted in a timely manner, and the mitigated consequences of the event are below chemical exposure standards.

Hot offgas flowing through the carbon adsorbers could cause bulk ignition and burning of the carbon media. This could result in a very rapid release of mercury. To preclude this initiator, offgas temperature is monitored at the inlet to the mercury abatement skid. On detection of high offgas temperature, automatic interlocks open the mercury abatement skid bypass valve and close the carbon adsorber inlet isolation valves. The setpoint for the high offgas temperature interlocks will be established at a temperature below the ignition temperature of the carbon media. Closing the isolation valves prevents flow of hot gas through the carbon media. The media will not reach temperatures capable of causing ignition. The bypass valve interlock ensures a continuous, un-obstructed flowpath for melter offgas, preventing pressurization of the melter and a potential NO_x release inside the facility. The offgas temperature monitor, carbon adsorber inlet inlet isolation valves and associated interlocks are designated ITS, classified as SDC.

The mercury abatement skid bypass valve interlocks from the carbon oxides (CO_x) monitors and offgas temperature monitor are classified as ITS, safety design significant (SDS). The bypass interlock supports the SDC function provided by the melter offgas system, by ensuring offgas flow is not obstructed. The bypass interlocks requirements are discussed in Section 4.4.8.

The mercury abatement skid high temperature isolation and bypass interlocks are required in addition to the CO_x monitor isolation and bypass interlocks. Exposure of the carbon media to a high temperature offgas stream could result in bulk burning of the carbon media and an unacceptable release of mercury before the CO_x monitor interlocks can respond, due to sample lag and the time required to close the isolation valves."

<u>Evaluation (acceptable):</u> This change evaluates the functional requirements against the design. The discussion is consistent with other changes reviewed in this SER and with the changes

described and evaluated in Section 3.1 above. The effects of nitrate accumulations in the carbon bed are discussed in Section 4.7 of this SER and required testing for unsafe ammonium nitrate accumulations is discussed in Section 5.0. It is appropriate to classify the by-pass valve and the deluge water shutoff valve and their associated instrumentation as SDS because failure of these valves would result in an SDC system (Secondary offgas) not performing its safety function. SRD Safety Criterion 1.0-6 states that an SDS SSC is one whose failure would directly prevent an SDC system from performing its safety function. The air inlet valves to the carbon beds and the COx and temperature monitors are appropriately classified as SDC because they prevent a fire in the bed an ultimate breakthrough of the beds and release to the environment.

4.14 Proposed Revised Text – Section 4.3.3.6, "Controls Related to TSRs":

The Contractor proposed to add the following text to this section to provide controls for the carbon bed fire:

> "For the carbon bed fire, the following controls must be imposed at the TSR level.
>
> - The mercury abatement skid carbon oxides (COx) monitoring function and interlocks to close the carbon adsorber inlet isolation valves must be operable whenever the carbon adsorbers contain activated carbon and are connected (inlet open) to the secondary offgas system. Operability requirements include periodic calibration of the COx monitoring instrumentation and functional testing of bypass and isolation valve interlocks. The ability of the bypass line to carry sufficient flow to prevent pressurizing the LAW melters must be verified periodically.
>
> - When the carbon adsorber inlet valves are closed by the COx monitor interlock, the total inleakage of oxygen into both carbon adsorbers, through the closed valves and pressure boundary, must be less than the inleakage value used in the accident analysis. This leakage requirement will be verified by periodic testing of the isolation valves and configuration control of the carbon adsorber bed exhaust line.
>
> - The mercury abatement skid high offgas temperature/isolation valve interlocks must be operable whenever the melters are operating or the HEPA filter preheaters are energized. The high temperature setpoint must be set at a temperature below the ignition temperature of the activated carbon media. Operability requirements include periodic calibration of the temperature instrumentation and functional testing of the isolation valve interlocks."

ORP reviewers modified the first bullet above to include periodic verification of the by-pass line to carry sufficient flow to prevent pressurization of the melters.

Evaluation (acceptable as modified): This change, with modifications, adds information describing Technical Safety Requirements (TSR) for the carbon bed fire. The by-pass modification is necessary to ensure the by-pass line is not plugged so that it can perform its safety function (convey offgas without pressurizing the melter plena) on demand. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.15 Proposed Revised Text – Section 4.4.2.1, "Credited Safety Function":

The Contractor proposed to add the following text to the end of the sixth bullet in this section to provide clarity regarding a requirement that isolation valves associated with the carbon beds must not fail in such a way to affect the safety function of maintaining an unobstructed flowpath in the offgas system.

- "This requirement does not apply to the offgas inlet valves to the activated carbon adsorbers, as these valves are relied on to shut off offgas flow through the adsorbers in the event of a fire. A bypass around the adsorber beds is provided to ensure an unobstructed flowpath when an adsorber bed supply valve is closed (see Section 4.4.8)"

Evaluation (acceptable): This change provides clarity regarding the role of the offgas inlet valves to the carbon beds to isolate the beds in the event of a fire or other event that dictates bypassing the carbon beds. The bypass valve provides the safety function to prevent obstruction of the flow path. The change is consistent with the credited safety functions described elsewhere in this SER and with the changes described and evaluated in Section 3.1 above.

4.16 Proposed Revised Text – Sections 4.4.8, "Mercury Abatement Skid Bypass," and its subsections:

These sections add the SDS SSCs for the Mercury Abatement Skid Bypass and the Carbon Adsorber Bed Liquid Level Control for internal design basis events. The proposed changes, four pages in length, are not being provided in this SER because of the length. The proposed pages are contained in Attachment 1 of the ABAR.

In addition, add to Section 4.4.8.3, "Functional Requirements" a fourth bullet to read as follows:

> "Liquid and solids must not be allowed to accumulate in the bypass piping to the point that that the flow path of the melter offgas is obstructed and the melter plena are pressurized."

In addition, to Section 4.4.8.6, "Controls Related to TSRs," add to the end of the second bullet the following:

> "Testing includes verification that the bypass line is able to provide an unobstructed flow path for melter offgas without pressurizing the melter plena."

The ORP reviewers added the above text to Sections 4.4.8.3 and 4.4.8.6 to provide added clarity and consistency with other changes made in this ABAR. The SDS SSCs will be designed to SC-III and meet QL-2 to ensure the offgas system meets its confinement and flow-path functions.

Evaluation (acceptable as modified): This change identified the SDS SSCs associated with the changes proposed in this ABAR. The change, with the modifications, is consistent with the changes described and evaluated in Section 3.1.

4.17 Proposed Revised Text – Appendix 4A, Table 4A-1:

Table 4A-1 provides a list of SDC SSCs. Three new entries were added to the table as indicated below:

Safety Design Class Structures, Systems, and Components Summary for LAW

Safety Design Class Structure, System, or Component	Credited Safety Function	Representative and Bounding Accident (Chapter 3)	Controls (Chapter 5)
Mercury abatement skid carbon oxides monitor/carbon adsorber isolation valve interlocks Section 4.3.3	CO_x monitors across the mercury abatement skid are relied on to detect production of CO_x in the bed, indicative of a carbon fire. On detection of elevated CO_x levels above a predetermined setpoint, a signal is sent through interlocks to fully close the offgas inlet isolation valves to both carbon adsorbers. This reduces oxygen flow to the fire and controls the release rate of mercury.	Carbon Bed Fire Analysis (section 3.4.1.3)	The CO_x monitors and carbon adsorber isolation valve interlocks must be operable whenever the carbon adsorbers contain activated carbon media and the offgas inlet is open.
Mercury abatement skid high temperature/carbon adsorber isolation valve interlocks Section 4.3.3	The temperature of the offgas flowing into the mercury abatement skid is monitored. On detection of high temperature (above predetermined setpoint) the offgas inlet valves to both carbon adsorbers are closed by interlock. This control prevents bulk ignition of the carbon media due to flow of hot offgas through the carbon media. The temperature setpoint will be established at a value below the ignition temperature of the carbon media.	Carbon Bed Fire Analysis (section 3.4.1.3)	The high temperature monitor and carbon adsorber isolation valve interlocks must be operable whenever any melter is operating or the HEPA preheaters are energized with an open flowpath through the mercury abatement skid.
Mercury abatement exhaust path Section 4.3.3	The combined oxygen inleakage rate into both carbon adsorbers, with the inlet isolation valves closed, must be less than the limiting value calculated in the accident analysis. The exhaust leg from the carbon adsorbers back to the secondary offgas system must be designed in a manner that limits backflow of oxygen (due to countercurrent flow or diffusion) such that the total inleakage rate used in the accident analysis is not exceeded.	Carbon Bed Fire Analysis (section 3.4.1.3)	Design Feature - Configuration Management AC

Evaluation (acceptable): This change adds technical details describing the SDC SSCs associated with the change described in this ABAR. The change is consistent with the changes to PSAR Section 4.3.3.1 and the general change described and evaluated in Section 3.1 above.

4.18 Proposed Revised Text – Appendix 4A, Table 4A-2:

Table 4A-2 provides a list of SDS SSCs. Two new entries were added to the table as indicated below:

Safety Design Significant Structures, Systems, and Components Summary for LAW

Safety Design Significant Structure, System, or Component	**Credited Safety Function**	**Representative and Bounding Accident (Chapter 3)**	**Controls (Chapter 5)**
Mercury abatement skid bypass interlock Section 4.4.8	Open bypass valve to direct melter offgas flow around the mercury abatement skid on detection of high differential pressure across the skid, high differential CO_x concentration across the skid, or high inlet offgas temperature. (Note: the CO_x monitors and offgas temperature monitor are SDC to mitigate carbon bed fires, see Table 4A-1).	Melter Offgas Release (section 3.4.1.1)	Pressure monitors across the bed and bypass valve interlocks must be operable whenever any melter is operating.
Carbon adsorber liquid level control. Section 4.4.9	Isolation valve on water addition line to the carbon adsorber is closed when high liquid level is detected in the carbon adsorber. Required to prevent flooding of the secondary offgas system with water.	Melter Offgas Release (section 3.4.1.1)	Carbon adsorber liquid level detector and water addition line isolation valve interlock must be operable whenever any melter is operating.

Evaluation (acceptable): This change adds technical details describing the SDS SSCs associated with the change described in this ABAR. The change is consistent with the changes described in PSAR Sections 4.4.8 and 4.4.9 and the general change described and evaluated in Section 3.1 above.

4.19 Proposed New Text – Section 5.5.7, “LCO – Mercury Abatement Skid Interlock Operability”:

This change adds LCO controls for the Mercury Abatement Skid Interlock Operability. The proposed change is as follows:

“LCO - Mercury Abatement Skid Interlock Operability

Purpose. This control is derived from the melter offgas release accident (section 3.4.1.1) and the carbon bed fire accident analysis (section 3.4.1.3).

A carbon bed fire event could result in a release of mercury exceeding the chemical exposure standards for the facility worker, co-located worker, and public receptor. Carbon oxides (CO_x) concentration monitors across the mercury abatement skid are relied on to detect a fire in the carbon adsorbers. On detection of significant CO_x

production in the carbon adsorbers, the offgas inlet isolation valves to both carbon adsorbers are shut via interlock. This action reduces the available oxygen to the carbon beds. Restricting the available oxygen to the carbon adsorbers limits the combustion rate of the carbon media and thus limits the release rate of mercury. The accident analysis in section 3.4.1.3 demonstrates that reducing the available oxygen is sufficient to reduce receptor exposures below the chemical exposure standards. In addition, the CO_x monitors are interlocked to open the mercury abatement skid bypass valve to ensure proper offgas flows when the skid is isolated (see below).

In addition, a HEPA filter pre-heater fault (preheater controller fails high) or operation of melters with low level in the submerged bed scrubber could result in offgas flowing through the carbon media at temperatures exceeding the ignition temperature of the carbon media. A high temperature interlock at the offgas inlet to the mercury abatement skid prevents high temperature offgas from flowing through the carbon adsorbers by automatically closing isolation valves on the carbon adsorber inlets. This prevents bulk ignition of the carbon media. In addition, the temperature monitoring instrumentation is interlocked to open the mercury abatement skid bypass valve to ensure proper offgas flows when the skid is isolated (see below).

A release of melter offgas may exceed the chemical exposure standards for both the facility worker and the co-located worker. The mercury abatement skid bypass valve is relied on to maintain an open flowpath from the melter to the exhaust stack in the event the mercury abatement skid components become plugged or offgas flow is blocked due to inadvertent or intentional closure of valves. Drawing flow from the melter through the melter offgas system prevents facility worker exposure to the chemical release. Elevated releases from the exhaust stack have been demonstrated (Chapter 3) to meet the chemical exposure standards for the co-located worker. The bypass valve is interlocked to (1) differential pressure monitors across the mercury abatement skid, (2) the differential CO_x concentration monitors across the mercury abatement skid, and (3) the offgas inlet temperature monitor to the mercury abatement skid. The first interlock ensures the mercury abatement skid is bypassed should the carbon beds plug or flood with water. The latter two interlocks, <u>and a means of ensuring an adequate flow path through the bypass leg</u>, ensure continuous, unobstructed melter offgas flow when the carbon adsorber inlet valves are closed by interlock to mitigate carbon bed fires.

Finally, flooding of the offgas flow path with water supplied to the carbon adsorbers is also an event of concern. On detection of high liquid level in the carbon bed, an isolation valve on the water addition line to the carbon adsorber is actuated to close. This prevents overflow of water into the secondary offgas piping, which could obstruct offgas flow and compromise the safety function provided by the offgas system.

The mercury abatement skid interlock controls consist of operability requirements with the following elements:

- The mercury abatement skid carbon oxides (CO_x) monitoring instrumentation across the mercury abatement skid shall be operable, providing a signal to close (via interlock) the carbon adsorber inlet isolation valves <u>after first opening</u> (via interlock) the bypass valve when the differential CO_x concentration across the skid exceeds a predetermined value.

- The mercury abatement skid offgas temperature monitor shall be operable, providing a signal to close (via interlock) the adsorber inlet isolation valves after first opening (via interlock) the bypass valve when the offgas feed temperature exceeds a predetermined value.

- The differential pressure monitors across the mercury abatement skid shall be operable, and shall send a signal to open the bypass valve (via interlock) on detection of high pressure drop across the skid.

- The carbon adsorber inlet isolation valve interlocks shall be operable, and shall close the offgas inlet valves to both carbon adsorber beds upon receiving (1) a high differential CO_x concentration signal from the mercury abatement skid CO_x monitors, or (2) a high temperature signal from the temperature monitor.

- The bypass valve interlocks shall be operable, and shall open the bypass valve directing offgas flow around the mercury abatement skid upon receiving (1) a high differential CO_x concentration signal from the mercury abatement skid CO_x monitors, (2) a high temperature signal from the temperature monitor, or (3) a high differential pressure signal from the differential pressure monitors across the mercury abatement skid.

- The carbon adsorber liquid level detectors shall be operable, and shall actuate (close) the isolation valve on the water addition line to the carbon adsorber on detection of liquid level at a predetermined setpoint.

- The water addition line isolation valve interlock shall be operable, and shall shut down the water supply to the carbon adsorber upon receiving a high level value from the carbon adsorber level instrumentation.

Surveillances related to the LCO include periodic calibration of the CO_x monitors, offgas temperature monitor, pressure monitors, and liquid level detectors to ensure accurate activation of the isolation and bypass valve interlocks. In addition, periodic functional testing of the mercury abatement skid isolation valve interlocks, bypass valve interlocks, bypass leg flow path, and water addition line isolation valve interlocks are necessary to ensure their proper function.

Periodic testing of the carbon adsorber inlet isolation valves is required to verify the closed valve leakage rate, under pressure simulating secondary offgas exhauster pressure, is within the bounds of the mitigated accident analysis.

These operability requirements and surveillances for the carbon oxides monitoring instrumentation apply for all operating modes of the LAW facility, whenever the carbon adsorbers contain activated carbon media and the offgas inlet to the carbon adsorbers is open.

The operability requirements and surveillances of the offgas temperature monitoring instrumentation apply whenever the mercury abatement skid is in use to treat melter offgas and whenever the HEPA filter preheater(s) are energized with an open exhaust flow through the mercury abatement skid.

The operability requirements and surveillances for the differential pressure instrumentation and carbon adsorber liquid level instrumentation apply to the LAW facility in the operation mode, whenever any melter is in a state of operation. When no melters are in a state of operation, there are no cold caps, and no melter offgas release of NO_x above exposure standards is possible.

Derivation Criteria. This control was selected to mitigate exposures to the co-located worker and public receptors (within the SRD chemical exposure standards) in the event of a carbon bed blockage or fire."

ORP reviewers made minor modifications to the proposed text (shown as underlined) to ensure the functionality of the bypass leg flow path, and to ensure the bypass valve is opened before the adsorber bed inlet valves are closed. This was not clear in the original proposed text.

<u>Evaluation (acceptable as modified):</u> The items designated to be operable are consistent with the changes described in the ABAR and follows DOE guidance for establishing LCOs. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.20 <u>Proposed Revised Text – Section 5.5.8.8, "AC – Carbon Adsorber Contols":</u>

This change adds administrative controls for the Mercury Abatement Skid to minimize the likelihood of carbon bed fires. The proposed change is as follows:

"AC - Carbon Adsorber Controls

Purpose. The need for controls on the carbon adsorber beds is derived from the accident analysis for a postulated carbon bed fire (3.4.1.3). Various administrative controls were selected to minimize the likelihood of carbon bed fires. The key administrative control elements for the carbon adsorbers include:

- Manual valves in the exhaust path from the carbon adsorbers must be locked open during mercury abatement skid use.
- An alternate vent path, directed away from operators, must be established prior to carbon adsorber isolation (i.e., closure of both inlet and outlet valves).
- Fresh activated carbon media must be verified to be free of contaminants reactive or incompatible with the carbon media or melter offgas before use.
- During use of the carbon adsorber startup preheater, airflow temperature must be monitored and the preheater current controlled to ensure the ignition temperature of the carbon media is not approached.
- Acceptable carbon media temperature must be verified before opening a carbon adsorber for maintenance or replacement of the carbon media.

- Used carbon media must be controlled per the facility's transient combustible program after removal from the carbon adsorber.

Derivation Criteria. These controls are relied on to reduce the risk of carbon bed fires associated with startup and maintenance activities on the carbon adsorber units."

Evaluation (acceptable): This change adds technical details describing the administrative controls to minimize carbon bed fires. The change is consistent with the changes described and evaluated in Section 3.1 above and elsewhere in this SER.

4.21 Proposed Added Text – Section 5.6.3, "Melter Offgas System":

Section 5.6 provides design features that are not covered elsewhere in the TSRs that, if altered or modified, would have a significant effect on safety. This change adds the design feature to minimize the backflow of oxygen. The following proposed bullet is to be added to the end of the section:

> "The design and configuration of the mercury abatement skid must minimize the potential backflow of oxygen (e.g., due to diffusion or countercurrent flow) into the carbon adsorbers via the carbon absorber outlet pipe to the secondary offgas header. The backflow of oxygen via this path, when combined with oxygen ingress due to isolation valve leakage, must be less than the limiting value determined in the Carbon Bed Fire accident analysis (section 3.4.1.3)."

Evaluation (acceptable): This change adds details describing the requirement to limit the backflow of oxygen to the Mercury Abatement Skid. The method that will be used to do this has not been finalized by the contractor. The change is consistent with the changes described and evaluated in Section 3.1 above.

4.22 Proposed Revised Text – Appendix 5A, Table 5A-1:

Table 5A-1 provides a list of the hazard and accident analysis and TSR cross reference. Three new entries were added to the table as indicated below:

Hazard and Accident Analysis and Technical Safety Requirement Cross Reference

Chapter 3 Section	Technical Safety Requirement	Control Basis
Melter Offgas Release 3.4.1.1	LCO, Mercury Abatement Skid Interlock Operability	This LCO provides controls to ensure melter offgases are directed to the exhaust stack. This control is necessary to lessen the likelihood of facility worker exposures and to lessen the consequences of co-located worker exposures.

Hazard and Accident Analysis and Technical Safety Requirement Cross Reference

Chapter 3 Section	Technical Safety Requirement	Control Basis
Carbon Bed Fire 3.4.1.3	LCO, Mercury Abatement Skid Interlock Operability	This LCO provides controls to ensure that air flow to the carbon absorbers is limited in the event of a fire in one of the carbon adsorbers. This control is necessary to lessen the consequence of facility worker, co-located worker, and public exposures. This LCO also provides controls to ensure that air flow temperatures the carbon absorbers are exposed to are limited to be below levels that could result in a carbon bed fire. This control is necessary to lessen the likelihood of facility worker, co-located worker, and public exposures. Finally, this LCO provides controls to ensure the mercury abatement skid is bypassed whenever offgas flow is obstructed due to closure of isolation valves to mitigate carbon bed fires. This control is necessary to lessen the likelihood of facility worker exposures and to lessen the consequences of co-located worker exposures.
	AC, Carbon Adsorber Controls	This AC is required to minimize the likelihood of carbon bed fires.

AC = Administrative Control
LCO = Limiting Condition for Operation

Evaluation (acceptable): This change is consistent with other changes described in this SER.

4.23 Minor Editorial Changes:

Minor editorial changes were proposed for various pages of the LAW PSAR. The specific areas editorial changes were made are listed in the following table:

Section No.	Specific location
3.3.3.2	Sixth paragraph
3.4.1.2	Section title
4.3.1.1	Bullet
4.3.1.5	First paragraph
4.3.2.1	Bullet
4.3.3.1	First bullet
4.3.3.3	Seventh bullet
4.3.3.4	Sixth bullet
4.4.1.1	First bullet
4.4.2.1	Last bullet
Table 4A-1	Several entries
Table 4A-2	First entry
5.5.1	First paragraph
5.5.8.4	First paragraph
5.5.8.5	First paragraph
Table 5A-1	First column, second row

Evaluation (acceptable): These editorial changes are acceptable because they do not affect the safety basis described in the document and add clarity and consistency.

5.0 CONCLUSIONS

On the basis of the considerations described above, the ORP has concluded there is reasonable assurance that the health and safety of the public, the workers and the environment will not be adversely affected by the changes proposed by ABAR 24590-WTP-SE-ENS-03-1261, Revision 0, and subsequent modifications defined in this SER and agreed to by the Contractor. The proposed changes, with the identified modifications, excluding the issue described in the Condition of Acceptance described below, do not constitute a significant reduction in commitment or effectiveness relative to the design, construction, and operation of ITS SSCs. Accordingly, the proposed changes, excluding the issue described in the Condition of Acceptance, are acceptable and the ORP approves the general design change and interim-approves the specific PSAR changes as proposed in 24590-WTP-SE-ENS-03-1261, Revision 0.

COA No.1 for this SER:

> By the next PSAR update, test for and quantify the amounts and rates of accumulation of ammonium nitrate in the carbon beds under bounding conditions. Evaluate the hazards and identify controls to mitigate the hazards, if any.

Testing is required because the presence of ammonium nitrate in the carbon beds could invalidate the fire model used by the Contractor since ammonium nitrate acts as an oxidizer and was not accounted for in the model. Approval of the ABAR is based upon completion of testing and using the test results to update the hazards analysis and identify controls, as necessary. It is recognized that valid testing cannot be accomplished until the design of the carbon beds, the type of carbon media to be used, and other design related issues are known. Based on this consideration and the likelihood that any new controls for mitigating an ammonium-nitrate-enhanced fire hazard are unlikely to require significant modifications to the carbon bed equipment, procurement of the carbon bed equipment is allowed except for the active ITS equipment for controlling a carbon bed fire. Procurement of the ITS equipment for controlling the fire is allowed once the testing is complete and any necessary control changes are approved by DOE.